Forest Pest Management
Pacific Northwest Region

DISEASE SURVEY OF THE BEAR TWO
AND LOUIE TIMBER SALE AREAS
TIETON RANGER DISTRICT
WENATCHEE NATIONAL FOREST
WASHINGTON

Disease Survey of the Bear Two and Louie Timber Sale Areas, Tieton Ranger District, Wenatchee National Forest, Washington

by

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ABSTRACT

Two timber sale areas were examined for tree diseases on the Tieton Ranger District. Important diseases found included laminated root rot in grand fir and Douglas-fir; dwarf mistletoe in Douglas-fir and western larch; and heart-rot in western hemlock and grand fir. Management alternatives concerning these diseases are discussed.

Introduction

As part of an evaluation of forest survey methods for measuring incidence of root diseases, two timber sale areas, Bear Two (T. 13 N., R. 13 E., sec. 16) and Louie (T. 13 N., R. 14 E., sec. 10), Figure 1, were surveyed for diseases on the Tieton Ranger District. Although these areas are scheduled for harvesting and management plans already have been formulated, we are submitting our disease survey information and management recommendations for future reference and possible use in similarly affected areas.

Both areas surveyed contain uneven-aged, mixed-conifer stands with grand fir (*Abies grandis*) predominating. Other species present include Douglas-fir (*Pseudotsuga menziesii*), ponderosa pine (*Pinus ponderosa*), western white pine (*P. monticola*), lodgepole pine (*P. contorta*), western larch (*Larix occidentalis*), Engelmann spruce (*Picea engelmannii*), western hemlock (*Tsuga heterophylla*), and western redcedar (*Thuja plicata*).

Although both sale areas were covered with ½ inch or more of volcanic ash from the May 18 eruption of Mount St. Helens, this did not hinder appreciably disease survey and diagnosis. Dust masks were worn frequently during the survey, and liberal amounts of soap and water were used following each day's work.

Objectives

Objectives in both sale areas were to:

1. Determine incidence (trees and basal area per acre) of important tree diseases and associated mortality over approximately a 20-year period.

2. Determine proportion of area affected by root diseases associated with tree mortality.

3. Formulate management recommendations for the diseases found in the survey.

Methods

Each sale area was surveyed using plots arranged on a 2 x 5 chain grid. Each plot consisted of a variable plot (BAF 40) and a fixed-area circular plot (1/100 acre). Plot centers were the same for both variable and fixed plots. Only trees greater than or equal to 5.0 in. DBH were measured on variable plots. Trees less than 5.0 in DBH but greater than or equal to 6 in. in height were measured on fixed-area plots.

The following data were collected for each plot tree: 1) tree species, 2) DBH (approximated for stumps), and 3) cause of infection or mortality. Trees or stumps with less than half of their circumference with intact bark at the root collar were considered to have been dead for more than 20 years and were not recorded.

In addition, as transects were followed, proportion of land area affected by root disease was estimated by measuring the length of transects that fell within affected areas and dividing this by the total length of the transect.

Affected area was that area surrounding each infected, dead, or dying tree or infected stump and corresponded to approximate rooting zones. Root diseases were detected by chopping at the root collar and by limited excavation and dissection of roots near the root collar. Only dead or nearly dead trees or stumps were examined for root diseases. No attempt was made to record possible root infection of living trees with no or only mild above-ground symptoms.

Armillaria root rot was detected by the presence of mycelial fans beneath the bark or by yellow, stringy decay in old, dead material. Laminated root rot was detected by the presence of ectotrophic mycelium on the surface of exposed roots or by characteristic laminated decay with setal hyphae in old, dead material. Annosus root rot was detected by the presence of white, stringy decay in old, dead material.

Bear Two Sale Area

Results and Discussion

Approximately 50 acres of the Bear Two Sale were surveyed systematically with 40 plots (0.8 plots per acre) on four transects. By use of the line-intercept method, we estimate at least 12.9 percent of the area is affected by root diseases. This figure is probably conservative, since only dead or dying trees and stumps were examined. Living but symptomless trees were not examined and some may be infected, especially *Phellinus*-tolerant species such as redcedar, white pine, and ponderosa pine.

Plot data revealed that 7.7 percent of the trees representing 12.3 percent of the basal area was infected by root diseases, especially laminated root rot caused by *Phellinus weirii*. Some *Fomes annosus* was also found (Tables 1 and 2). Other pests killed 15.2 percent of the stems and 27.0 percent of the basal area. Larch dwarf mistletoe (*Arceuthobium laricis*), Douglas-fir dwarf mistletoe (*A. douglasii*), mountain pine beetle (*Dendroctonus ponderosae*), and white pine blister rust (*Cronartium ribicola*) were noted on dead trees; however most trees in this category had been harvested and may have been alive when logged.

Incidence of root diseases in grand fir, the primary species in the area, was slighty less than that in Douglas-fir (Tables 1 and 2); however, in grand fir, root diseases were in standing trees whereas most of the root diseases found in Douglas-fir were found in stumps of harvested trees. It appears that even though Douglas-fir may become infected by *P. weirii* at an equal or higher rate than grand fir, East Side Douglas-fir is not quite as susceptible to root disease-caused mortality as is grand fir (Filip 1979). No root diseases were observed in western hemlock, redcedar, white pine, ponderosa pine, or Engelmann spruce.

There was no root disease-caused mortality in trees less than 11 in. DBH in the Bear Two Sale Area, and incidence of disease increased with increasing diameter class. One possible explanation for this is that as trees grow and their root systems expand, the chances of contact with buried inoculum or infected roots of adjacent trees increases. Damage caused by dwarf mistletoe and mountain pine beetle was the most serious in the larger size classes.

Conclusions and Recommendations

The stands examined in the Bear Two Sale Area are in a general state of decline, characteristic of overmature forests. Some of the root diseases, particularly laminated root rot, are causing tree mortality, especially in grand fir. However, there are many intermediately susceptible (larch, spruce, hemlock), tolerant (white pine), and resistant (ponderosa pine, redcedar) trees in the area that can be favored, thus reducing infection and mortality in the future stand (Hadfield and Johnson 1977). Some of the Douglas-fir and much of the larch has dwarf mistletoe which is causing severe growth loss and tree mortality. If these species are regenerated, care should be taken to prevent spread of dwarf mistletoe to the regeneration.

The following management alternatives for disease reduction are presented for the Bear Two Sale Area in increasing order of cost and effectiveness of reducing diseases:

1. No treatment. Based on what is happening now in the stand, losses due to root disease-caused tree mortality should average 0.5 trees/acre/year or 1 ft. ^{2}/acre/year of basal area. This excludes growth loss in infected living trees, loss due to butt decay caused by root diseases, and losses due to dwarf mistletoe. About 13 percent of the land area will remain affected by root diseases. Losses probably will remain constant if the forest is left undisturbed.

2. Sanitation-salvage. Most of the wood loss sustained if the above treatment is used will be captured with sanitation-salvage. However, loss caused by root diseases will continue in the present stand.

3. Seed tree or shelterwood systems discriminating against grand fir and Douglas-fir. Most of the merchantable timber will be harvested in one or a few operations. Future losses will decrease since grand fir and Douglas-fir are most susceptible to root disease and they will be replaced by tree species less susceptible to laminated root rot. Some loss may be expected as a result of windthrow of infected residual trees. Loss of leave trees may be decreased even further if special care is taken to mark leave trees that are low risk to root diseases based on their proximity to infected trees or stumps. Dwarf mistletoe-infected overstory trees should be removed before susceptible understory reaches 3 feet tall or 10 years old, whichever occurs first. If white pine is retained, care should be taken to select blister rust-free trees and remove trees before they reach 16 inches DBH or 120-140 years old to prevent mortality caused by mountain pine beetle.

4. Clearcutting and replanting. All of the merchantable timber will be harvested in one operation. Grand fir and Douglas-fir should not be used for regeneration. Some reestablishment of these species will occur at unit margins. Although some infection and mortality will occur as the new stand matures, it will be reduced if grand fir and Douglas-fir are discriminated against. This alternative is most effective in reducing dwarf mistletoe damage.

5. Seed-tree, shelterwood, or clearcut systems with stump removal. This alternative will be the most effective in reducing infection and mortality caused by root diseases in residuals and regeneration, including grand fir and Douglas-fir, and hence the future stand by removing the bulk of fungus inoculum from the soil. However, because of the abundance of species tolerant of or resistant to laminated root rot on the site, stump removal may not be warranted in this situation.

Louie Sale Area

Results and Discussion

Approximately 100 acres of the Louie Sale Area were surveyed systematically with 80 plots (0.8 plots per acre), on eight transects. By use of the line intercept method, we estimate at least 6.4 percent of the area is affected by root diseases. As explained earlier, this estimate may be conservative. Plot data revealed that 5.4 percent of the trees representing 7.3 percent of the basal area were infected by root diseases, primarily laminated root rot and Armillaria root rot caused by *Armillaria mellea* (Tables 3 and 4). Again, some *Fomes annosus* was found.

Other pests killed 24.4 percent of the trees representing 27.0 percent of the basal area. Although causal agents for most of this loss could not be identified, mountain pine beetle *(Dendroctonus ponderosae)* caused appreciable mortality in western white pine and lodgepole pine as did dwarf mistletoe *(Arceuthobium laricis)* in western larch.

Douglas-fir dwarf mistletoe *(A. douglasii)* was present in 40.0 percent of the Douglas-fir representing 41.1 percent of the basal area, two-thirds of which were killed by this organism. Although growth loss due to dwarf mistletoe in living trees was not measured, it may be as much as 50- to 60-percent of the basal area as found in Montana (Pierce 1960).

Another disease of significance in the sale area was the Indian paint fungus, *Echinodontium tinctorium*. At least 3.0 percent of the grand fir representing 7.5 percent of its basal area and 14.1 percent of the western hemlock representing 24.1 percent of its basal area had heartrot caused by *E. tinctorium* as indicated by conks. More trees may be infected and decayed since only trees with conks were recorded.

As in the Bear Two Sale Area, incidence of root diseases was highest in grand fir, the primary species, and Douglas-fir. Much of the Armillaria root rot found in Douglas-fir occurred in stumps of harvested trees, probably acting as a saprophyte. There was more laminated root rot found in Douglas-fir than grand fir on a tree basis, but not on a basal area basis. Some *Fomes annosus* was found in both grand fir and Douglas-fir. No root disease-caused mortality was found in western hemlock, western larch, Engelmann spruce, white pine, ponderosa pine, or lodgepole pine.

Incidence of all diseases appeared to increase with DBH class. Heartrot caused by *E. tinctorium* and incidence of dwarf mistletoe become more damaging as stands mature. Also, mature and overmature white pine are highly susceptible to mountain pine beetle.

Conclusions and Recommendations

As with the Bear Two Sale Area, stands examined in the Louie Sale Area are in a general state of decline. Root disease losses were less in Louie than in Bear Two, but more dwarf mistletoe, Indian paint fungus, and mountain pine beetle were noted in Louie than in Bear Two. An abundance of root disease-resistant species exists on the site that can be used to minimize future losses. Stand replacement will reduce the heartrot and dwarf mistletoe problem provided care is taken to prevent reinfection of regeneration. Short rotations of 150 years or less also will minimize losses due to heart rot.

The following management alternatives for disease reduction are presented for the Louie Sale Area in increasing order of cost and effectiveness of reducing diseases:

1. No treatment. Losses due to root disease-caused tree mortality should average 0.8 trees/acre/year or 0.7 ft. ^{2}/acre/year of basal area. This excludes growth loss of infected living trees and loss due to butt decay caused by root disease. About 7 percent of the land area will remain affected by root diseases. Losses due to dwarf mistletoe-caused mortality in Douglas-fir alone will average 0.3 trees/acre/year or 0.3 ft.^{2}/acre/year of basal area. This excludes growth loss in living infected trees. Losses due to dwarf mistletoe, heartrot, and mortality caused by mountain pine beetle will accelerate as trees become overmature.

2. Sanitation-salvage. Most of the wood loss sustained above will be captured, especially that caused by dwarf mistletoes, heartrots, and mountain pine beetle. However, loss caused by root diseases will continue in the present stand.

3. Seed tree or shelterwood systems discriminating against grand fir and Douglas-fir. Most of the merchantable timber will be harvested in one or a few operations. Future losses caused by root diseases will decrease since grand fir and Douglas-fir are most susceptible and they will be replaced by tree species less susceptible to laminated root rot. Some loss may be expected as a result of windthrow of root disease infected residual trees. Loss of leave trees may be decreased even further if special care is taken to mark leave trees that are low risk to root diseases, based on their proximity to infected trees or stumps. Dwarf mistletoe-infected overstory trees should be removed before susceptible understory reaches 3 feet tall or 10 years old, whichever occurs first. If hemlock is grown, care should be taken to avoid wounding residuals or regeneration in order to reduce infection and decay caused by *E. tinctorium*. If white pine is retained, care should be taken to select blister rust-free trees and remove trees before they reach 16 inches DBH or 120-140 years old to prevent mortality caused by mountain pine beetle.

4. Clearcutting and replanting. All of the merchantable timber will be harvested in one operation. Grand fir and Douglas-fir should not be used for regeneration. Some reestablishment of these species will occur at unit margins. Although some infection and mortality from root diseases will occur as the new stand matures, it will be reduced if grand fir and Douglas-fir are discriminated against. This alternative is most effective in reducing dwarf mistletoe and heartrot.

5. Seed tree, shelterwood, or clearcut systems with stump removal. This alternative will be the most effective in reducing infection and mortality caused by root disease in residuals and regeneration, including grand fir and Douglas-fir, and hence the future stand by removing the bulk of fungus inoculum from the soil. However, because of the abundance of tree species tolerant of or resistant to laminated root rot on the site, stump removal may not be warranted. Also, the steep topography in some areas will limit stump removal operations.

The information and recommendations presented in this report have been specifically formulated for the area we surveyed. Although some of this information may be applied to other areas in Oregon and Washington experiencing similar root disease problems, these areas may be sufficiently

different from the area we surveyed to warrant a separate biological evaluation to formulate management alternatives specific to that area. Forest Pest Management pathologists encourage and are available to perform such evaluations at the request of land managers.

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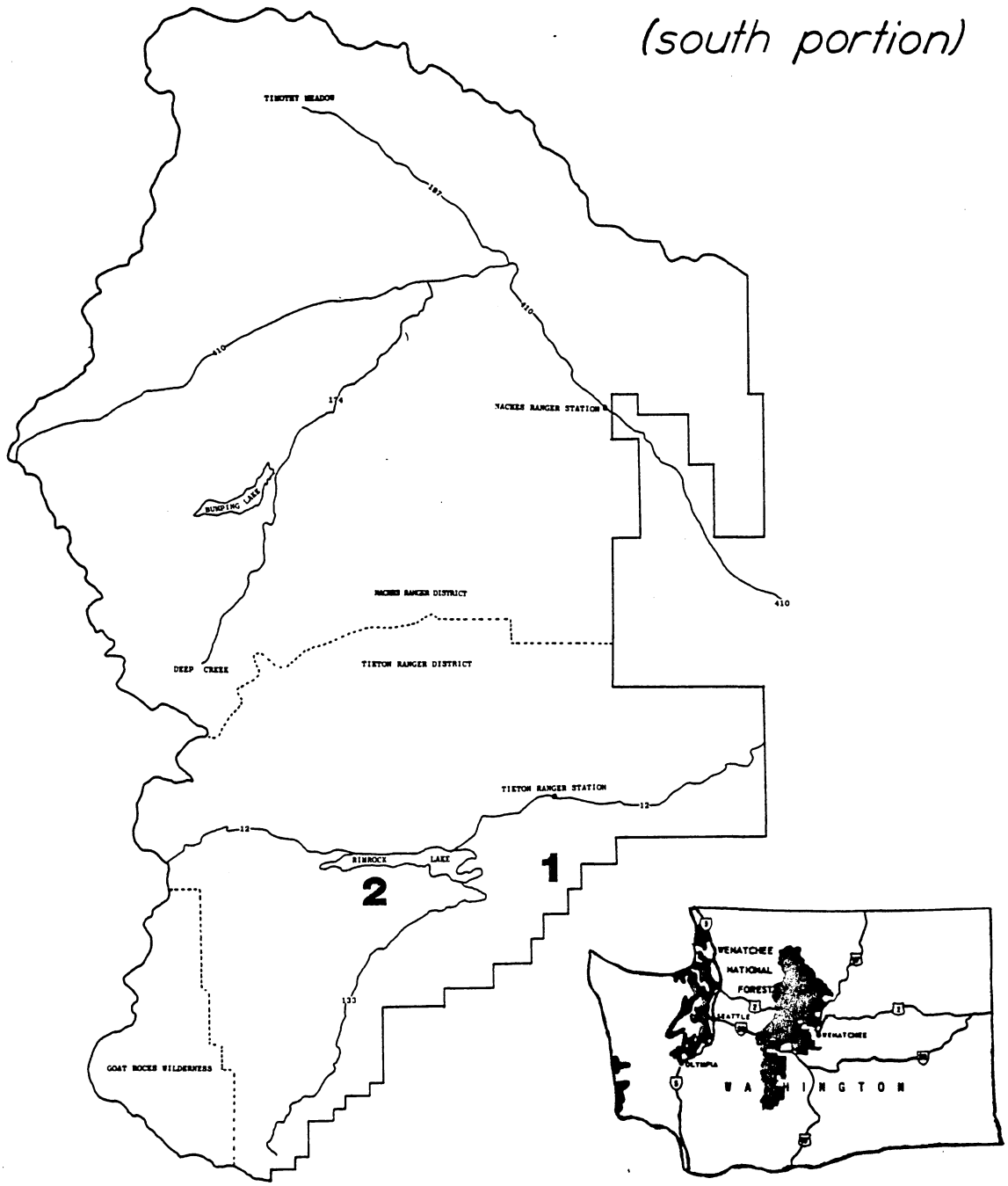

Figure 1--Map depicting areas surveyed;
1 = Louie Sale, 2 = Bear Two Sale

Table 1--Basal Area ($ft.^2$) Per Acre by Tree Species, DBH Class, and Condition in the Bear Two Sale Area

DBH Class (In.)	All Species				Grand fir				Douglas-fir				Ponderosa Pine		White Pine		Other[b] Species	
	HL	PW	FA	OT[a]	HL	PW	FA	OT	HL	PW	FA	OT	HL	OT	HL	OT	HL	OT
	basal area (ft^2) per acre																	
5.0-10.9	47	0	0	2	43	0	0	1	0	0	0	0	0	0	0	0	4	1
11.0-20.9	70	9	2	17	46	8	2	8	11	1	0	4	1	0	6	1	6	4
21.0-30.9	36	15	4	39	13	7	2	3	12	8	2	25	6	8	2	1	3	2
31.0-40.9	27	3	1	23	3	1	1	2	12	2	0	21	7	0	1	0	4	0
41.0-50.9	2	1	2	0	0	0	1	0	0	1	1	0	0	0	0	0	2	0
Total	182	28	9	81	105	16	6	14	35	12	3	50	14	8	9	2	19	7
Percent	60.7	9.3	3.0	27.0	74.5	11.3	4.3	9.9	35.0	12.0	3.0	50.0	63.6	36.4	81.8	18.2	73.1	26.9

HL = Healthy
PW = *Phellinus weirii*
FA = *Fomes annosus*
OT = Other

[a]Larch and Douglas-fir dwarf mistletoe, mountain pine beetle, and white pine blister rust were noted on dead trees; however, most trees in this category are harvested trees, especially Douglas-fir.

[b]Other species include western larch, western hemlock, western redcedar, and Engelmann spruce.

Table 2--Stems Per Acre by Tree Species, DBH Class, and Condition in the Bear Two Sale Area

DBH Class (In.)	All Species				Grand fir				Douglas-fir				Ponderosa Pine		White Pine		Other[b] Species	
	HL	PW	FA	OT[a]	HL	PW	FA	OT	HL	PW	FA	OT	HL	OT	HL	OT	HL	OT
	stems per acre																	
0-0.9	552.5	0	0	5.0	490.0	0	0	0	0	0	0	0	17.5	0	0	0	45.0	5.0
1.0-4.9	197.5	0	0	0	195.0	0	0	0	0	0	0	0	2.5	0	0	0	0	0
5.0-10.9	92.5	0	0	5.8	75.4	0	0	2.9	0	0	0	0	0	0	0	0	17.1	2.9
11.0-20.9	55.1	8.5	1.4	12.5	39.3	7.6	1.4	5.4	8.4	0.9	0	3.3	0.7	0	2.8	0.5	3.9	3.3
21.0-30.9	9.6	4.2	1.1	10.0	3.7	2.1	0.6	0.7	3.3	2.1	0.5	6.4	1.5	1.8	0.4	0.3	0.7	0.8
31.0-40.9	4.1	0.4	0.1	3.6	0.5	0.2	0.1	0.3	1.8	0.2	0	3.1	1.1	0	0	0	0.7	0.2
41.0-50.9	0.2	0.2	0.1	0	0	0	0.1	0	0	0.2	0	0	0	0	0	0	0.2	0
Total[c]	161.5	13.3	2.7	31.9	118.9	9.9	2.2	9.3	13.5	3.4	0.5	12.8	3.3	1.8	3.2	0.8	22.6	7.2
Percent	77.1	6.4	1.3	15.2	84.7	7.1	1.6	6.6	44.7	11.2	1.7	42.4	64.7	35.3	80.0	20.0	75.8	24.2

HL = Healthy
PW = *Phellinus weirii*
FA = *Fomes annosus*
OT = Other

[a] Evidence of larch and Douglas-fir dwarf mistletoe, mountain pine beetle, and white pine blister rust were noted on dead trees; however, most trees in this category are harvested trees, especially Douglas-fir.

[b] Other species include western larch, western hemlock, western redcedar, and Engelmann spruce.

[c] Totals only include DBH class 5.0-50.9

Table 3--Basal Area ($ft.^2$) Per Acre by Tree Species, DBH Class, and Condition in the Louie Sale Area

DBH Class (In.)	All Species								Grand fir						Douglas-fir							Western Hemlock			White Pine		Other[b] Species	
	HL	PW	AM	FA	ET	D-DM	L-DM	OT[a]	HL	PW	AM	FA	ET	OT	HL	PW	AM	FA	D-DM	L-DM	OT	HL	ET	OT	HL	OT	HL	OT
	basal area (ft^2) per acre																											
5.0-11.9	46.5	1.5	1.0	0	1.0	1.0	1.5	14.0	41.5	0.5	1.0	0	1.0	7.5	0.5	1.0	0	0	1.0	1.5	2.5	3.5	0	0	1.0	3.5	0	0.5
11.0-20.9	50.0	4.0	4.5	0.5	7.5	3.0	5.5	38.0	28.5	3.0	2.5	0.5	5.0	18.5	3.0	1.0	2.0	0	3.0	5.5	8.0	5.5	2.5	0	7.5	4.0	5.5	7.5
21.0-30.9	23.0	3.0	1.0	0.5	3.0	1.5	6.0	11.0	5.0	3.0	0	0.5	2.0	3.0	5.0	0	1.0	0	1.5	6.0	5.5	2.0	1.0	0	4.5	2.5	6.5	0
31.0-40.9	2.0	0	0.5	1.0	1.5	0.5	2.5	1.5	0.5	0	0.5	0	1.5	0.5	0	0	0	1.0	0.5	2.5	1.0	0	0	0	1.5	0	0	0
41.0-50.9	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0
Total	121.5	8.5	7.0	2.0	13.0	6.0	16.0	64.5	75.5	6.5	4.0	1.0	9.5	29.5	8.5	2.0	3.0	1.0	6.0	16.0	17.0	11.0	3.5	0	14.5	10.0	12.0	8.0
Percent	51.0	3.6	2.9	0.8	5.5	2.5	6.7	27.0	59.9	5.2	3.2	0.8	7.5	23.4	15.9	3.7	5.6	1.9	11.2	29.9	31.8	75.9	24.1	0	59.2	40.8	60.0	40.0

HL = Healthy
PW = *Phellinus weirii*
FA = *Fomes annosus*
OT = Other
ET = *Echinodontium tinctorium*
D-DM = Dead with dwarf mistletoe
L-DM = Live with dwarf mistletoe
AM = *Armillaria mellea*

[a] Evidence of larch dwarf mistletoe, mountain pine beetle, and white pine blister rust were noted on some dead trees, however, most had no readily identifiable cause.

[b] Other species include western larch, western redcedar, Engelmann spruce, lodgepole pine, and ponderosa pine.

Table 4--Stems Per Acre by Tree Species, DBH class, and Condition in the Louie Sale Area

DBH Class (In.)	All Species								Grand fir						Douglas-fir							Western Hemlock			White Pine		Other[b] Species	
	HL	PW	AM	FA	ET	D-DM	L-DM	OT[a]	HL	PW	AM	FA	ET	OT	HL	PW	AM	FA	D-DM	L-DM	OT	HL	ET	OT	HL	OT	HL	OT
	stems per acre																											
0-0.9	315.1	0	1.3	0	0	0	0	11.3	255.0	0	1.3	0	0	11.3	20.0	0	0	0	0	0	0	21.3	0	0	12.5	0	6.3	0
1.0-4.9	228.9	2.5	6.3	1.3	0	0	1.3	23.8	213.8	2.5	6.3	1.3	0	21.3	0	0	0	0	0	1.3	0	8.8	0	2.5	5.0	0	1.3	0
5.0-10.9	151.0	3.7	3.9	0	1.8	3.5	4.4	50.9	140.1	1.4	3.9	0	1.8	27.5	0.9	2.3	0	0	3.5	4.4	8.3	8.6	0	0	1.4	8.6	0	6.5
11.0-20.9	42.4	4.0	3.8	0.5	5.8	2.1	3.5	24.0	27.2	3.1	2.4	0.5	4.1	13.5	1.4	0.9	1.4	0	2.1	3.5	5.2	3.5	1.7	0	5.9	2.7	4.4	2.6
21.0-30.9	7.2	0.9	0.3	0.1	1.0	0.3	1.9	3.9	1.6	0.9	0	0.1	0.6	1.0	1.7	0	0.3	0	0.3	1.9	1.6	0.7	0.4	0	1.3	1.0	1.9	0
31.0-40.9	0.4	0	0	0.2	0.3	0.1	0.4	0.3	0.1	0	0	0	0.3	0.1	0	0	0	0.2	0.1	0.4	0.2	0	0	0	0.3	0	0	0
41.0-50.9	0	0	0	0	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0	0	0	0	0	0	0	0
Total[c]	201.0	8.6	8.0	0.8	8.9	6.0	10.3	78.8	169.0	5.4	6.3	0.6	6.8	42.1	4.0	3.2	1.7	0.2	6.0	10.3	15.3	12.8	2.1	2.5	8.9	12.3	6.3	9.1
Percent	62.3	2.7	2.5	0.2	2.8	1.9	3.2	24.4	73.4	2.3	2.7	0.3	3.0	18.3	9.8	7.9	4.2	0.5	14.7	25.3	37.6	73.6	12.1	14.3	42.0	58.0	40.9	59.1

HL = Healthy
PW = *Phellinus weirii*
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D-DM = Dead with dwarf mistletoe
L-DM = Live with dwarf mistletoe
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[a]Evidence of larch dwarf mistletoe, mountain pine beetle, and white pine blister rust were noted on some dead trees, however most had no readily identifiable cause.

[b]Other species include western larch, western redcedar, Engelmann spruce, lodgepole pine, and ponderosa pine.

[c]Totals only include DBH class 5.0-50.9.